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ABSTRACT

Recent reports by the National Science Teacher's Association, the National Science Foundation, and the National Education Goals Panel indicate that the science preparation of American children is deficient. In 1990 the State of California published the "Science Framework" guide to curriculum and materials in an effort to address these deficiencies in the science programs in the state's public schools. The guide is modeled after Project 2061, sponsored by the American Association for the Advancement of Science (AAAS). California devised its Framework to be the master criteria book as the backbone of its six-year plan to freshen, revamp, and improve teaching of the sciences. The Framework emphasizes a thematic approach. The elements of reform include: (1) instructional materials (a state panel evaluates all materials to ensure they comply with and encourage the aims of the Framework); (2) teacher development; (3) technology in the schools; (4) assessment program (assessing the success and cohesiveness of the scientific program on a statewide basis, assessing how Framework reaches its goals, and altering the state assessment program to fit the Framework); and (5) statewide implementation (staff development workshops). The tight state budget is the major obstacle blocking implementation of the Framework. (MDH)

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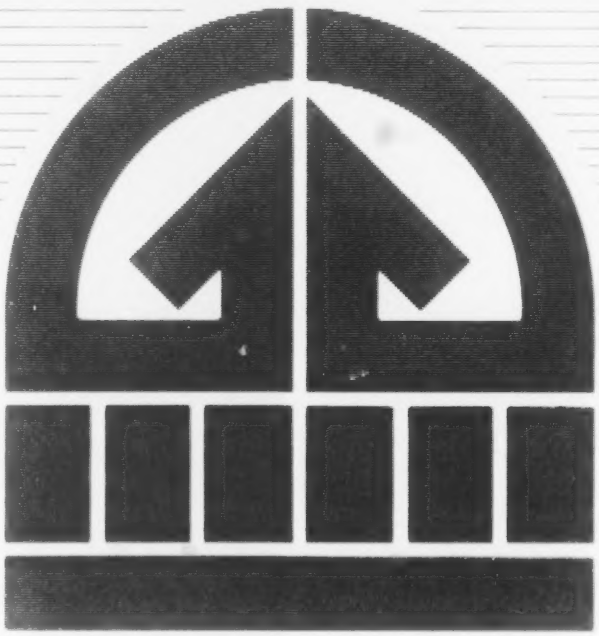

THE CALIFORNIA FRAMEWORK FOR SCIENCE EDUCATION

by
James B. Reed, Senior Policy Specialist
and
John A. Calhoon, Research Assistant

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An Information Service of the National Conference of State Legislatures
1560 Broadway, Suite 700, Denver, Colorado 80202. William T. Pound, Executive Director

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THE CALIFORNIA FRAMEWORK FOR SCIENCE EDUCATION

Introduction

A litany of surveys and studies indicate the need for a greater emphasis on science education in American public schools. Our nation is struggling to keep up with international competition and rapidly progressing technological standards. The Science Teacher's Association warns that the emerging workforce may lack the technical background and analytical skills necessary in today's market. The National Science Teacher's Association (NSTA) estimates that the nation will need 300,000 science and math teachers by the year 1995, exceeding by far their present numbers. The National Science Foundation estimates that America will produce 225,000 fewer engineering graduates than necessary to be competitive. The report of the National Education Goals Panel released in September 1991 shows that American students continue to lag behind their international counterparts in mathematics.

Comparative testing repeatedly reveals the deficiencies in nearly every aspect of science education in the United States. Children are not captivated by the wonders of science, are not drawn to pursue science fields as a career, and are not keeping up with their international counterparts. Worse, children, and even adults, demonstrate a disappointing degree of illiteracy in the field of science, even in the most basic concepts necessary in any walk of life.

The statistics are familiar by now. Schools are experiencing significant decreases in the numbers of students enrolling in science courses and a relative decline in achievement test scores. The NSTA estimates that in 1986 nearly a third of the nation's high school students did not take a physics course, 17.5 percent did not take a course in chemistry and 8 percent did not take a course in biology. The Educational Testing Service (ETS) reports in its *Science Report Card* , that "more than one-half of the nation's 17-year-olds appear to be inadequately prepared to perform competently in jobs that require technical skills, or to benefit substantially from specialized on-the-job training, and only 7 percent of the nation's 17-year-olds have the prerequisite knowledge thought to be necessary to perform well in college level science courses." The nation consistently has ranked at the bottom in science preparation compared to the rest of the industrialized world.

In the classroom, the National Science Foundation found that on the average, U.S. elementary schools devote approximately 15 minutes a day to science. In 1986 the NSTA found that the majority of science teachers at the precollege level rated their preparation for teaching science only as adequate to minimal. By age 17, roughly one-half of the males, but only one-third of the females, demonstrate the ability to analyze scientific data and procedures, and there is growing evidence of differential treatment and opportunities in science instruction for women and ethnic minorities.

Developments in California

California is one state, among many, that is taking bold measures to dramatically re-direct the path of science in public schools. The California Legislature and the California State Department of Education are aggressively making efforts to alleviate perpetual problems and deficiencies in the science programs of the state's public schools.

Despite tight economic times for California public education, the state published the *Science Framework* guide to curriculum and materials in 1990. It is modeled after Project 2061, sponsored by the American Association for the Advancement of Science (AAAS). Project 2061 is a comprehensive effort to reform nearly every aspect of the science education process in the

United States. One result of Phase I of Project 2061, completed in 1989, was the report, *Science for all Americans*, which describes the nature of scientific illiteracy in the United States, and outlines a plan to emphasize understanding, general comprehension and thinking skills over rote memorization and objective learning. California is one of several states that has set out to address the "failure" of science education by reviewing its own approach and then refocusing it along the parameters set forth by *Science for All Americans.*

In 1989, the California State Board of Education devised its *Science Framework* master criteria book as the backbone of a six-year plan to freshen, revamp and improve teaching of the sciences in the public schools. *Science Framework* emphasizes a thematic approach to teaching science and it sets standards for making science education participatory, 'minds on' and interesting for every student. *Science Framework* and its six-year implementation plan will provide an early example of the goals, objectives and methods set forth by *Science for all Americans*.

The California Science Framework

Science Framework is a valuable guide for science educators in California and it serves as a clear statement of principle, but its primary audience is publishers and producers of public school science materials. It clearly indicates what type of teaching materials will be necessary and it serves as the standard for judging materials submitted for use in coming years. The guidebook is a comprehensive document that addresses every aspect of science education, from defining science illiteracy to proposing teaching methods that alleviate it. The intent is to reform California science education to allow students to do science rather than read about it, and to think and problem solve rather than simply memorize and reproduce. It emphasizes the importance of science in other intellectual pursuits, as well as the interdisciplinary dependency of each of the divisions of the sciences.

The framework also mandates more student participation in place of lectures and memorization. Extensive studies indicate that students whose classroom activities are challenging and participatory are more likely to have a higher science proficiency. However, reading texts is the primary science activity of most students surveyed, while hands-on experimentation and use of technical equipment is relatively rare.

According to the director of the State Science Assessment Program in California, many students display a tendency to do well in sciences simply by memorizing and then repeating the material. Studies of instances in which the material was manipulated to force students to apply the knowledge they had been taught revealed that many students reverted back to former misconceptions. *Science Framework* strives to eliminate this by refocusing on teaching students how to think scientifically, and by striving to teach students a more comprehensive, integrated understanding of the concepts of science. This approach will not only provide more students with the capacity to think scientifically, but it will also provide students with tools useful in the future both in and outside of science-related fields.

In addition, *Science Framework* clearly establishes the goal of improving overall representation of all students in the sciences. It states that there are too many subtle reminders to minority and female students that only white males can succeed at science. California sets a new standard of making science education "accessible to all students, especially those underrepresented in science-related fields."

Elements of Reform

Instructional Materials The State Board of Education approves all teaching materials for statewide use in kindergarten through eighth grade and provides guidelines for grades nine

through 12. The school districts themselves then purchase necessary materials from the pool of approved resources.

Instructional Materials Evaluation Panels (IMEPs) will be looking to see that materials comply with and encourage the aims of *Science Framework*. Among the materials selected are those that:

- o Identify commonly shared values of the scientific community;
- o Promote scientific values in the classroom;
- o Develop rational decision-making skills applicable to major issues of personal and public concern;
- o Approach the instruction of science in an integrative manner;
- o Promote the success and scientific self-esteem of every student.

This year, IMEPs consist of science teachers and science education specialists from throughout the state who make recommendations to the Board of Education. They review such materials as texts, manuals, technology resources, videos, laser disks, audio-visual materials, and other learning and teaching resources.

In December 1991, publishers produced a list of materials they intend to submit for the final deadline of April 10, 1992. Between April and August of 1992, the State Department of Education will undertake an extensive review process of the materials to assess how well they conform to the goals set by the *Science Framework*.

Teachers It is possible that "old guard" teachers or departments might be hesitant to change their ways. Tom Sachse, director of the Science Education Unit of the State Department of Education, says, however, that teachers are not satisfied with the status quo. National and international assessment tests have clearly made the point that students are not adequately grounded in science and any resistance to change on the part of the teachers is not due to complacency, but from not knowing where to begin to remedy the problem. *Science Framework* provides the necessary structure for change. Also, science teachers, by nature of their trade, tend to be more open to new ideas and approaches. Updates in approach should pose little difficulty for the science community.

Elementary teachers pose the most difficult problem in the reform puzzle. Grade school teachers are burdened with teaching all subjects. They are often inexperienced or simply uncomfortable for a variety of reasons with teaching science, particularly in the engaging manner demanded by *Science Framework*. Furthermore, grade school teachers occasionally complain of not having enough time to commit to elaborate science lessons. The Department of Education's plan for promoting the framework in elementary school will also depend upon teacher training and improved materials. Teachers will be given additional staff development seminars so they are comfortable with the premises of *Science Framework*. New materials resulting from the guidebook are intended, according to one science education consultant, to be more manipulable and applicable to the needs of an elementary teacher trying to teach "hands-on" science.

Technology in the Schools Hardware for teaching science and technological literacy is expensive. The State Department of Education theorizes that teacher familiarity, comfort and use of technological resources must occur through gradual implementation of the *Science Framework*

program. Lessons eventually will demand updating technological resources, so districts can obtain them gradually.

A school district's major purchases will depend upon what projects and experiments publishers come up with, so as yet there is no set list of necessary resources. But these technological resources should address the need for active learning so students can manipulate problems and do higher problem solving rather than simply feeding in objective answers.

One example is a Decision Development Corporation (DDC) product called Science 2000. Science 2000 is a software series being developed for seventh grade science programs that allows students to experiment with and manipulate problems. DDC is working closely with the State Board of Education to complement the needs of *Science Framework*.

The Assessment Program There are three tiers to the evaluation process that must be addressed: assessing the success and cohesiveness of the scientific program on a statewide basis, assessing how *Science Framework* reaches its goal of changing the way students learn science, and determining how assessments must change to measure those abilities that are now considered most important.

The state assessment program is being adopted to fit the *Science Framework*. Extensive efforts are underway to rewrite state tests to assess students' ability to think and to assess actual learning as defined by *Science Framework*. State assessments will consist of fewer multiple choice objective questions. Questions will be written to measure not only what students know, but how they think and how they reach the answers they do.

Using the precepts of the *Science Framework* as a guide, the assessors worked with sixth grade classes across the state and began developing a new testing style. One thousand schools participated in the experiment where students had to manipulate materials and perform hands-on tasks at 35 different stations. The students worked individually at each of the rotating stations. Nine hundred and eighty teachers were incorporated into the project. They were given a day of training, a day in the testing situation as a facilitator and then a day of debriefing. Teacher input was collected and noted. One suggestion was to follow the lead of *Science Framework* and allow students to collaborate on the problem solving parts.

A larger experiment involving 2,000 students, was conducted the following year. In general, the reaction from students and teachers alike was very positive . The department is determining how to incorporate the findings into a statewide program emphasizing more performance and less objective answers and more thought-based and open-ended questions.

Emphasis on active performance assessment programs means testing also will be more subjective and harder to score. Therefore, more teachers will be trained to be facilitators and scorers. Scoring, based on a rubric of possible answer characteristics, will be consistent across the state. Other assessment programs have used similar approaches with much success, including the national high school Advanced Placement Program and the California State Language Arts Assessments.

The alternative assessment approach of measuring performance and thought skills is mandated by legislation passed by the state Legislature last year. Senate Bill 662, sponsored by Senator Gary Hart requires "performance-based assessment," that is, testing aimed at demonstrating a pupil's knowledge and skills by writing a response to an essay question, conducting an experiment, constructing a diagram or model, or orally explaining a solution to a problem.

Efforts also are underway in a cooperative effort among the California, Illinois and Michigan state school boards and legislatures to develop multiple choice testing procedures to complement the overall *Science Framework* approach. Basically, the intent is to make multiple choice testing more thematic by identifying "big ideas" or "key concepts"--such as energy or photosynthesis--outlined in the *Science Framework* and then develop clusters of integrated thematic multiple choice questions around that concept.

Another alternative assessment approach being developed is the use of portfolios. This fall, sample school districts will participate in a trial program in which students collect their best work in a portfolio and then have an opportunity to revisit and expand upon that work by using the new knowledge acquired. It is an opportunity to integrate the testing process, as well to force students to think. The State Department of Education proposes to maintain ongoing staff development and training workshops to ensure that testing processes, materials and resources are most effectively used and applied.

Many officials have high hopes that the new assessment program not only will be more effective and useful, but that it will be more functional. By enabling testers to provide students with constructive feedback, the testing process will provide the state with the necessary aggregate information about students' comparative ability. An efficient program promises to reduce the number of testing sessions necessary for students while providing the same information as in the past.

Statewide Implementation The Department of Education has begun to implement a number of different staff development workshops around the state in an effort to prepare curriculum specialists to pass on the information and familiarize as many staff as possible with the tenets of the *Science Framework*. Both the STA and the Science Teachers Network are conducting workshops for teacher development. Programs such as California Science Implementation Network and Scope, Sequence and Coordination and nearly a dozen other more localized but similar approaches to *Science Framework* already have trained or exposed many teachers to the new thematic and active learning approaches.

The Outlook

The key problem blocking rapid implementation of the *Science Framework* is a tight state budget. As a result of California's Proposition 13 in 1979, funding for school districts shifted from local sources to state funding and the ability of districts to fund necessary costs was significantly inhibited. Many schools face dire economic circumstances; some 15 schools are currently on the brink of bankruptcy. Insufficient funding for most schools' science curriculums makes it difficult to implement comprehensive science reforms. California's 1991 budget deficit put pressure on education funding, but legislators budgeted $18.4 million for the 1991-1992 fiscal year, thus meeting the requirement that the state provide 40 percent of the general fund for schools, as mandated by Proposition 98. A paper transfer of $1.2 billion into the new school year was engineered to satisfy Proposition 98.

Presently, schools can use 70 percent of their state allocation to purchase resources approved by the State Board which usually does not include a great deal of advanced technology--and use the remaining 30 percent as discretionary funds. The discretionary funds commonly have been many schools' only source of funding for technological resources. Legislation signed by Governor Pete Wilson last year allows technology-based materials to be included as a part of a school district's overall purchase of instructional materials.

California efforts are likely to have an impact on publishers. The state Board of Education is working with states such as Texas and Florida to coordinate their demands of the publishers. Arizona also is implementing reforms, but is waiting to assess the materials California purchases.

California is one example of a science reform approach that other states might wish to examine. In addition, national efforts such as *Science for All Americans* help create a climate for reforming science education.

CONTACTS

California Department of Education
721 Capitol Mall
P.O. Box 944272
Sacramento, CA 94244-2720
916/445-4688

Bill Andrews
Science education consultant to California
State Department of Education
916/327-1863

Kathy Comfort, director
California State Science Assessment Programs
916/323-2333

Tom Sachse, manager
Science Education Unit
California State Department of Education
916/445-4688

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